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RESEARCH DEPARTMENT

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(RA-64)

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Summary

The design of a new medium-frequency aerial system for Moorside Edge is described. The effect of the hilly nature of the surrounding area on the performance of the aerials is discussed, and it is concluded that no advantage could be gained by centre-feeding.

1. Introduction

The medium-frequency transmitting station at Moorside Edge, near Huddersfield, radiates Radio 1 on 1214 kHz and Radio 4 on 692 kHz. The aerial system was originally supported on three masts erected in 1930. All three masts have had to be replaced because of corrosion due to their industrial environment.

The opportunity was taken to examine the aerial design in the light of more recent knowledge. An improved design has been specified and only two masts are now required.

2. The original aerial system

The Radio 1 aerial consisted of two wires supported from a 152 m (500 ft) mast as shown in Fig. 1. The two wires were driven in antiphase, giving a 'figure-of-eight' horizontal radiation pattern with maxima directed towards the main population centres of Lancashire and Yorkshire, and minima in directions served by co-channel transmitters. The mast is earthed and has no influence on the radiation pattern, because the currents induced in it by the two wires are in antiphase and therefore cancel one another.

The Radio 4 aerial was a T aerial supported between two 152 m (500 ft) masts spaced 183 m (600 ft). At 692 kHz this aerial was electrically equivalent to a mast radiator 0·375λ high.

3. The new aerial system

The new Radio 1 aerial is an exact replica of the original aerial, described in Section 2 and illustrated in Fig. 1. The plane containing the vertical wires lies on a bearing of 63°30' ETN. At 1214 kHz the horizontal spacing between the wires is 0·31λ and their height is 0·39λ. Satisfactory operation would be possible at any frequency from 1·0 MHz to 1·6 MHz (the upper end of the m.f. band).

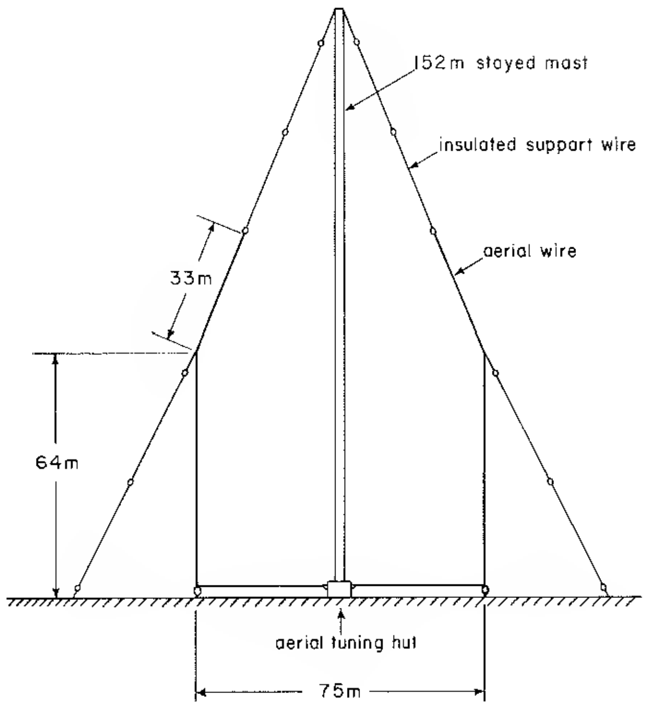

Fig. 1 - The Radio 1 Aerial

The new Radio 4 aerial is a base-fed mast-radiator whose effective height can be varied within certain limits to allow for possible frequency changes. The design of the aerial is similar to that of the Radio 3 aerial at Daventry,[1] but no provision has been made for centre-feeding, for reasons discussed in Section 5. The base and stay insulators have been designed to withstand a power input of 300 kW. The height of the mast is 206 m (675 ft) but the upper 15 m (50 ft) may be removed in three stages if operation on a higher frequency is required. A six-arm capacitance top is also fitted; three or six arms may be raised, or it may remain lowered. With six arms raised the effective height of the mast is increased by 17 m (55 ft) and operation on a lower frequency is possible.

At 692 kHz the height of the mast (with the top section complete) is 0·475λ. This is the optimum height at this frequency for an antifading aerial on ground of poor conductivity, as at Moorside Edge.* No advantage is to be gained by using an antifading mast at present, however, because the service area is severely limited by co-channel interference. While this situation persists it would be advantageous to raise all six capacitance-top arms, as this will increase the ground-wave field strength by 0·4 dB.

With three arms raised the effective height is increased by 9 m (30 ft), giving the optimum height for an antifading mast at 647 kHz, at present used elsewhere for Radio 3. With six arms raised the mast would be of optimum height at about 625 kHz, and its performance would be satisfactory down to 530 kHz (the lower end of the m.f. band).

Removal of all or part of the upper 15 m would enable the mast to be used up to 750 kHz with optimum fading-free performance. The shortened mast could be used up to 900 kHz if anti-fading characteristics were not required. Operation at higher frequencies would not be practicable because the ground-wave field-strength would be severely reduced.

4. The earth systems

The new aerials had to be erected on slightly different sites in order to preserve continuity of service. Consequently new earth systems had to be laid.

It has been shown theoretically[2] that little is to be gained by using earth systems of more than 0·2λ radius for base-fed aerials whose heights approximate to half a wavelength, even with ground of poor conductivity. Earth systems of this radius with 72 radial wires were therefore specified.

The earth system for the Radio 1 aerial consists of two sets of radial wires originating from points below the vertical sections of the aerial wires (Fig. 1). The two sets extend to a radius of 49 m (160 ft) except where they would overlap; here the two sets of wires are joined. The earth system for the Radio 4 aerial is centred on the base of the mast and extends to a radius of 91 m (300 ft).

The outer ends of adjacent pairs of wires of both earth systems are joined; this permits continuity tests to be made from the centres of the systems. The wires are buried to a minimum depth of 30 cm (1 ft) and are of 0·26 mm (0·104 in) bare copper. Copper plates and earthing rods are also buried at the central points.

* The measured ground conductivity in the vicinity of Moorside Edge is 10^{-3} S/m

5. The effect of the site on the performance of the aerials

Moorside Edge is a spur of the Pennines and has an altitude of 335 m (1100 ft). The ground falls steeply on both sides by about 200 m (650 ft) and then rises to other spurs. These height variations are comparable with the wavelength at medium frequencies and have a significant effect on vertical radiation patterns (v.r.p.s).

Had the height variations been less than 0·05λ, the ground could have been regarded as flat. A worthwhile reduction in high-angle radiation could then have been achieved by centre-feeding the Radio 4 aerial; in the absence of co-channel interference this would have resulted in a considerable increase in the night-time service area.

Although it seemed unlikely that the full advantage could be gained by centre feeding, because of the irregular terrain, it was just possible that the degradation of the performance of a centre-fed aerial might not be too serious. Theoretical v.r.p.s for a centre-fed aerial were therefore computed,* taking ground contours into account. The method used is essentially the same as that employed in 1953 to study the effect of height variations at Daventry,[3] but the use of a digital computer enabled a much more comprehensive study to be made.

The method may be briefly described as follows: The compensation theorem[4] is used to determine how the mutual impedance between the mast radiator and an elevated aerial changes when flat perfectly-conducting ground is replaced by irregular imperfectly-conducting ground. The v.r.p. for the aerial on the irregular site is then calculated by applying this impedance change to the theoretical v.r.p. for a flat perfectly-conducting site.

The computation of each point on the v.r.p. requires the numerical integration of a function containing height data, over an area surrounding the aerial. This area may be quite large, because the integration must be extended to the radius where the ground wave field strength is at least 14 dB below the value for perfectly-conducting ground, if errors are to be avoided. With poorly-conducting ground this radius is 15 km at 692 kHz; a much greater radius would have been required in an area of high conductivity. Height data were therefore specified to a radius of 16 km (10 miles) at 0·16 km (0·1 mile) intervals on a complete set of radials spaced 10° apart, and all these points were included in the integration.

In Fig. 2, v.r.p.s for a 0·5λ centre-fed aerial, computed in four directions from Moorside Edge, are compared with the theoretical v.r.p. for the same aerial on a flat site of the same conductivity. Although the

* By Dr A.D. Olver.

computed v.r.p.s must be regarded as approximations because of the limitations of the theoretical method, they indicate that the irregular ground would cause a considerable increase in high-angle radiation in all directions. Since the high-angle radiation from a base-fed mast at Moorside Edge will be similar, the use of a centre-fed aerial would offer no advantage.

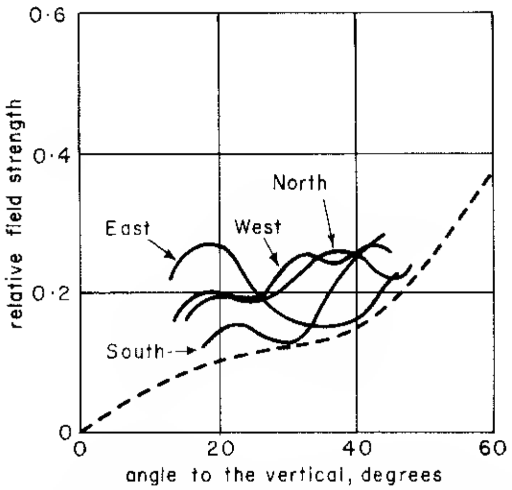

Fig. 2 - Computed v.r.p.s for a centre-fed aerial

——— v.r.p.s computed for the irregular terrain at Moorside Edge

- - - - - Theoretical v.r.p. for a flat site

6. Conclusions and recommendations

The Radio 1 aerial, which has a directional horizontal radiation pattern, may be used at any frequency within the range 1·0 to 1·6 MHz.

The new Radio 4 aerial is a base-fed antifading mast radiator. No advantage would have been gained by centre-feeding it because of the hilly nature of the surrounding terrain.

Simple structural modifications enable the Radio 4 aerial to be used with optimum antifading characteristics at any frequency between 530 and 750 kHz. Operation up to 900 kHz is possible if the antifading performance is sacrificed.

For operation on 692 kHz it is recommended that six capacitance arms should be extended while co-channel interference persists. If the interference ceases the arms should be lowered. If 647 kHz transmissions are radiated, three arms should be raised in the absence of interference.

7. References

1. Interim report on Daventry Third Programme mast radiator. BBC Research Department Report No. E-040, Serial No. 1951/12.

2. MONTEATH, G.D. 1957. The effect of the ground constants, and of an earth system, on the performance of a vertical medium-wave aerial. *Proc. Instn. elect. Engrs*, 1958, **105**, Part C, 7, pp. 292-306.

3. PAGE, H. *and* MONTEATH, G.D. 1954. The vertical radiation patterns of medium-wave broadcasting aerials. *Proc. Instn. elect. Engrs*, 1954, **102**, Part B, 3, pp. 279-297.

4. MONTEATH, G.D. 1951. Application of the compensation theorem to certain radiation and propagation problems. *Proc. Instn. elect. Engrs*, **98**, Part IV, 1, pp. 23-30.

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